CLAIMS

1. A method of optimising a model of a pipe network with respect to a predetermined criteria, the method comprising modifying a starting proposal for a list of pipes within the network model which may be modified by performing the following operations:

i) selecting a first pipe from the pipe list which may be considered for modification;

ii) proposing a modification to the selected pipe which provides an incremental improvement in said criteria;

iii) performing a network analysis of at least one predetermined operating parameter of the network to predict whether a predefined operating limit of said operating parameter will be violated as a result of the modification;

iv) if said network analysis predicts a violation of said predefined operating limit, then rejecting the proposed modification and removing the respective pipe from consideration for any further modification;

v) selecting a next pipe from the pipe list which may be considered for modification and performing operations (ii) to (iv) on the selected pipe;

vi) repeating operation (v) until all pipes which may be considered for modification have been selected; and

vii) repeating operations (i) and (vi) until no pipes of the pipe list remain to be considered for further modification.

2. A method according to claim 1, wherein the pipes are selected for modification in an order based on the hydraulic significance of each pipe within the network model.

3. A method according to claim 2, wherein the pipe ordering is the reverse of their hydraulic significance.

4. A method according to claim 2 or claim 3, wherein the hydraulic significance of each pipe in the pipe list is determined in accordance with the method of any one of claims 24 to 28.

5. A method according to any preceding claim, wherein the modification of operation (ii) is selected from a database of possible modifications.

6. A method according to claim 5, wherein the possible modifications are ordered in said database by reference to the magnitude of the improvement they provide in said criteria.

7. A method according to claim 6, wherein the modification operation (ii) comprises selecting from the database of possible modifications the modification which provides the smallest improvement in said criteria.

8. A method according to any one of claims 5 to 7, wherein the criteria is cost and the modification operation (ii) proposes a modification selected from a database of possible modifications and their associated costs, wherein the selected modification is the modification providing the smallest decrease in costs from the current proposal.

9. A method according to any preceding claim, wherein said at least one predetermined operating parameter includes one or more of a maximum acceptable hydraulic gradient, minimum and maximum permissible pressures specified for elements of the network, minimum and maximum flow rates through particular elements of the network, minimum tank levels and minimum and maximum permissible pipe sizes.

10. A method according to any preceding claim, wherein said at least one predetermined operating parameter is the peak flow rate any particular pipe must be able to provide, and wherein the peak flow rate for each pipe is determined according to the method of any one of claims 29 to 35.

11. A method according to any preceding claim, wherein the starting proposal is selected as the proposal offering the greatest optimisation of said predetermined criteria from a database of possible proposals available for consideration.

12. A method according to claim 11 or claim 12, wherein said starting proposal is taken as an initial starting proposal and further comprising the operations of:

a) performing a first revision of the initial starting proposal to revise the proposal for at least some of the pipes in the pipe list to a proposal less likely to result in a violation of said predefined operating limit;

b) performing a network analysis of said at least one predetermined operating parameter of the network to predict whether the predefined operating limit will be violated on the basis of said first revision;

c) if said network analysis predicts a violation of said predefined operating limit, then performing a second revision of the starting proposal for each pipe in the list, said second revision comprising adopting a proposal for each pipe which is least likely to produce a violation in said predefined operating limit from the possible proposals available for consideration.

13. A method according to claim 12, wherein the pipe list comprises existing pipes selected for rehabilitation within the pipe network and further comprising the following operations;

d) performing a network analysis to determine whether the second revision of the starting proposal is predicted to result in a violation of said at least one predefined operating limit;

e) if no operating limit violation is predicted, adopting said second revision as the starting proposal, otherwise performing a third revision of the starting proposal corresponding to the existing pipes in the network;

f) performing a network analysis to determine whether the existing network is predicted as producing a violation of said at least one predefined operating limit; and

g) if the network analysis predicts a violation then adopting the second revision as the starting proposal, otherwise increasing the size of each pipe proposal above the size of the corresponding existing pipe by a single size step.

14. A method according to claim 12 or claim 13, wherein in performing said first revision the proposal for each of the pipes in the pipe list is revised by proposing an increased size for each pipe compared to the size proposed for the initial starting proposal.

15. A method according to claim 14, wherein in performing the first revision the proposal for a selection of the most hydraulically significant pipes is increased in size by a greater magnitude than the proposal for pipes of lesser hydraulic significance.

16. A method according to any preceding claim, wherein the list of pipes comprises every pipe in the network model.

17. A method according to any one of claims 1 to 15, wherein the list of pipes comprises a selection of pipes from the network model.

18. A method according to claim 17, wherein the pipe list comprises a selection of pipes to be rehabilitated within the network modelled by the network model.

19. A method according to claim 17 or claim 18, wherein the pipe list is compiled by performing a filter operation on the full pipe list to select pipes satisfying specified filter conditions.

20. A method according to any preceding claim, wherein said network model is a part of a larger network or network model.

21. A method according to any preceding claim, wherein the network modelled is a water supply and/or distribution network.

22. A method according to claim 21, wherein the network is a model of a predefined metering district of a water supply and/or distribution network.

23. A method according to any preceding claim, wherein said predetermined criteria is the cost of installing or rehabilitating pipes within the network, or of operating the network.

24. A method of determining the hydraulic significance of each of a list of pipes within a model of a pipe network, the method comprising:

i) performing a network analysis on the network model to determine the flow patterns through the network at a given time;

ii) counting the number of instances of each pipe occurring in a flow path between a source node defined by the network model and the boundary of the network model, and using the instance count for each pipe as the indication of the hydraulic significance of that pipe within the network, such that pipes with a higher instance count are considered to more hydraulically significant than pipes with a lower instance count.

25. A method according to claim 24, wherein operations (i) and (ii) are performed for a number of different times over a predetermined time period and the instance count of each pipe determined at each time is summed to give a total instance count

for each pipe which is used as an indication of a hydraulic significance of that pipe within the network.

26. A method according to claim 25, wherein the times are 30 minute intervals over a 24 hour period modelled by the network.

27. A method according to anyone of claims 24 to 26, wherein the instance count is made by considering each node defined by the network model in turn and the pipe or pipes which converge or terminate at each node, and increasing the instance count for each pipe occurring at least once in a flow path to that node through the or each pipe terminating or converging at that node.

28. A method according to any one of claims 24 to 26, wherein the instance count is made by considering each pipe in turn and implementing the instance count for each pipe occurring at least once in a flow path through the selected pipe.

29. A method of determining peak flow rate demands on pipes within a model of a pipe network, the method comprising:

a) totalling the peak flow for the whole network and distributing this across the network to give a network peak flow demand on each pipe;

b) deriving a local peak flow demand representative of the localised demand on each pipe of the network; and

c) combining the network peak flow demand with the local peak flow demand to arrive at a peak flow rate demand for each pipe in the network.

30. A method according to claim 29, wherein the determination of the local peak demand flow comprises:

a) performing a network analysis on the network model at the peak flow time to determine the network peak flow pattern;

b) identifying each source or pseudo-source within the network model.

c) identifying each node which receives convergent in flows from two or more pipes within the network model;

d) treating each source and/or node identified above as the origin of a pipe tree having one or more branches each comprising one or more pipes, each branch terminating at a downstream convergent node or terminal node;

e) estimating the local demand on each pipe tree branch and assuming this estimate to be the local peak flow demand for each pipe in the respective branch.

31. A method according to claim 30, wherein the local peak demand for each pipe is estimated by determining the relative demand of the users supplied by each pipe in a pipe tree branch, and estimating the required flow through each pipe in the pipe tree branch required to meet the local demand on the pipe tree branch.

32. A method according to claim 31, wherein said estimating comprises combining the direct local peak demand on each pipe in a pipe tree branch with an indirect local demand on each pipe which is the contribution made by flow through the respective pipe to the direct local demand on each downstream pipe in the same pipe tree branch.

33. A method according to any one of claims 30 to 32, wherein the network peak flow demand is determined by estimating the through flow through each pipe tree branch required to meet network demand downstream of the branch, giving a branch through flow demand, and for each pipe summing the branch through flow demand

for each branch of which that pipe is a part to arrive at the network peak demand for that pipe.

34. A method according to claim 33, wherein the branch through flow is taken to be the contribution made by the flow through that branch to the network flow immediately downstream of the node at which the branch terminates.

35. A method according to claim 34, wherein said contribution is obtained as the ratio of the flow through the downstream pipe of the branch to the total network flow converging at the node at which the downstream pipe of the branch terminates, multiplied by the total network flow immediately downstream of the node.

36. A computer program comprising computer readable program code for executing a method according to any preceding claim.

37. A program storage device readable by a machine and encoding a program of instructions for executing the method according to any one of claims 1 to 35.

38. A computer system comprising means for operating a method according to any one of claims 1 to 35.

39. A method of optimising a pipe network, substantially as hereinbefore described.

40. A method of optimising a rehabilitation strategy for a pipe network, substantially as hereinbefore described.

41. A method of determining the hydraulic significance of pipes within a pipe network, substantially as hereinbefore described.

42. A method of estimating the peak flow demand on each pipe within a pipe network, substantially as hereinbefore described.